



Chemical Reactivity of Lunar Dust as it Pertains to Biological Systems

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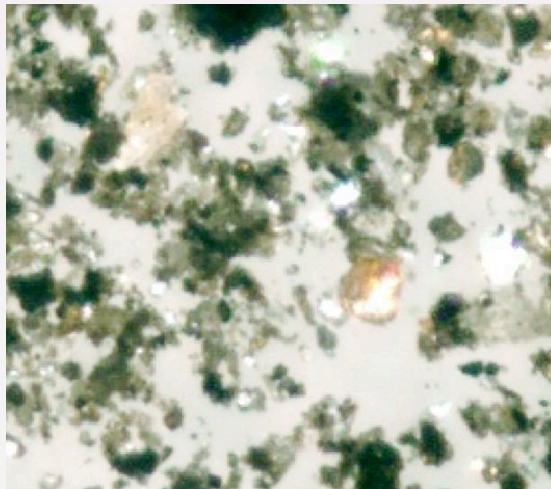
NLSI Lunar Science Conference
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Lunar Dust – What's the big deal?



Lunar Dust...



...Just a bunch of sand?



Lunar Dust – the Apollo Experience



Gene Cernan
Apollo 17





Lunar Dust – the Apollo Experience

“Dust – I think probably the most aggravating, restricting facets of lunar surface explorations is the dust and its **adherence to everything no matter what kind of material, whether it be skin, suit material, metal, no matter what it be and it’s restrictive friction-like action to everything it gets on. . .**

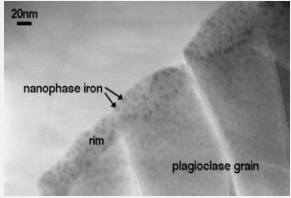
You have to live with it but you’re constantly fighting the dust problem **both outside and inside the spacecraft.** Once you get inside the spacecraft, as much as you can dust yourself, you start taking off the suits and you have dust on your hands and your face and your walking in it. You can be as careful in cleaning up as you want to, **but it just sort of inhabits every nook and cranny in the spacecraft and every pore in your skin”**

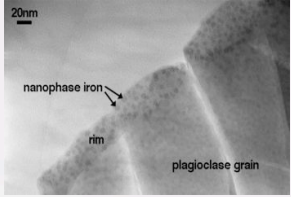
**Gene Cernan
Apollo 17 Technical Debrief**



Lunar Dust—What is it?

Lunar Dust Chemical Composition Major Components

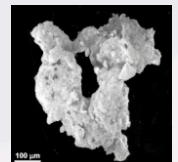
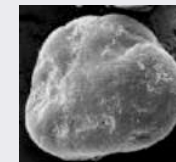
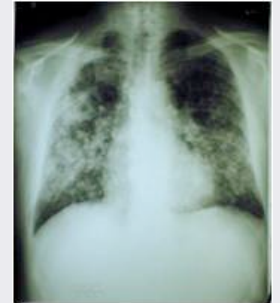
SiO₂	~45%
Al₂O₃	~15%
MgO	~10%
CaO	~10%
Fe-metallic ("nanophase iron")	~10% 



Lunar Dust—*Pulmonary Toxicity*

Silica (SiO_2)

- One of the most toxic inhaled substances
- Triggers inflammation in the lungs (macrophages and epithelial cells)
 - > Acute respiratory compromise?
 - > Fibrosis (scarring): “**Silicosis**”
- Particle size distribution is important ($<3\mu\text{m}$)
- Dust morphology is important (e.g., asbestos)
- Chemical reactivity **very** is important!



Hawk's Nest Tunnel, WV

- Dry grinding of quartz
 - *enhanced chemical reactivity**
- No respiratory protection

Result: Acute Silicoproteinosis (rapidly fatal)

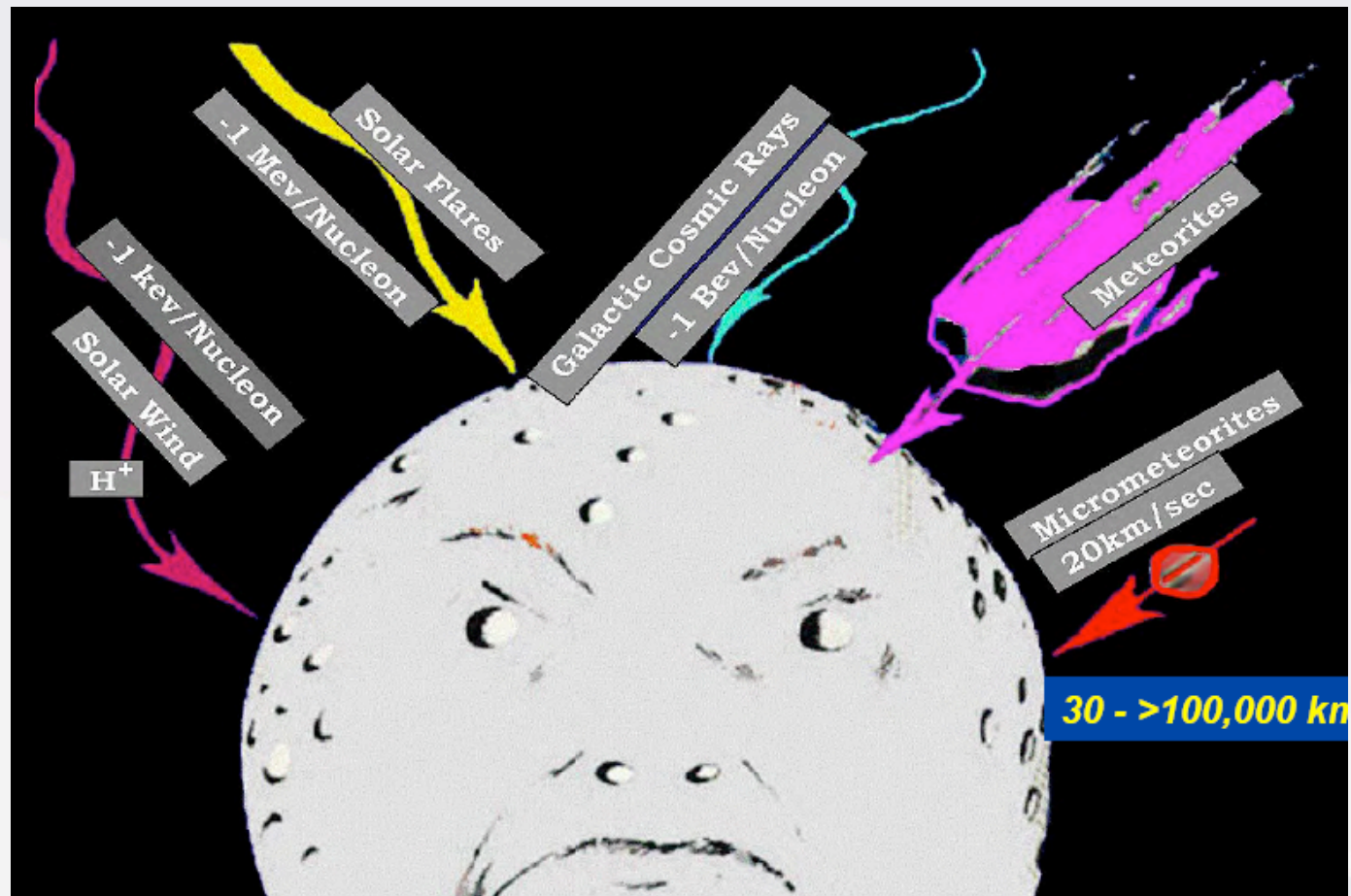
--More than 400 workers died

--One of the worst industrial disasters in U.S. history



What makes lunar dust chemically reactive?

- Chemical composition of lunar dust
- The effects of solar wind and other sources of radiation
 - The hard vacuum of the Moon





What happens when lunar dust surface radicals react with water?

Lunar dust surface radicals $\xrightarrow{\text{H}_2\text{O}}$ “reactive species”

Hydroperoxyl: HO_2^\bullet

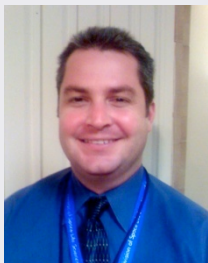
Superoxide anions: $\text{O}_2^{\bullet-}$

Hydroxyl radicals: OH^\bullet



Strategies for analyzing Lunar Dust

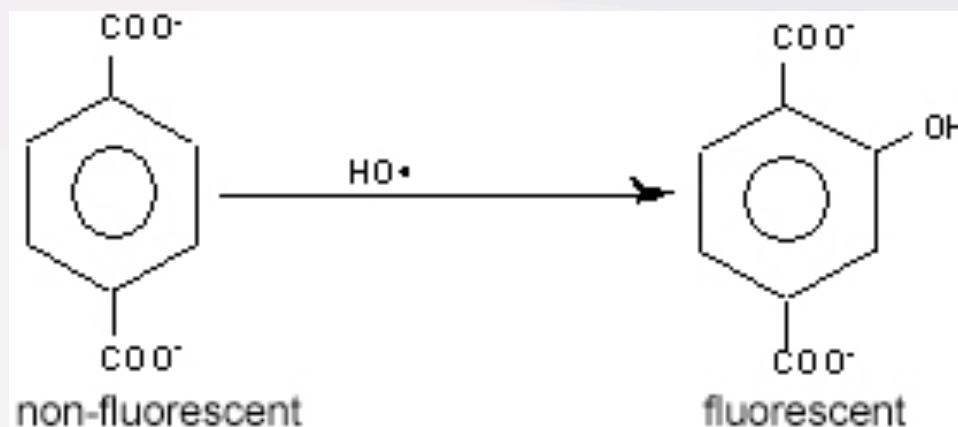
Chemical Reactivity



Dr. William Wallace
JSC

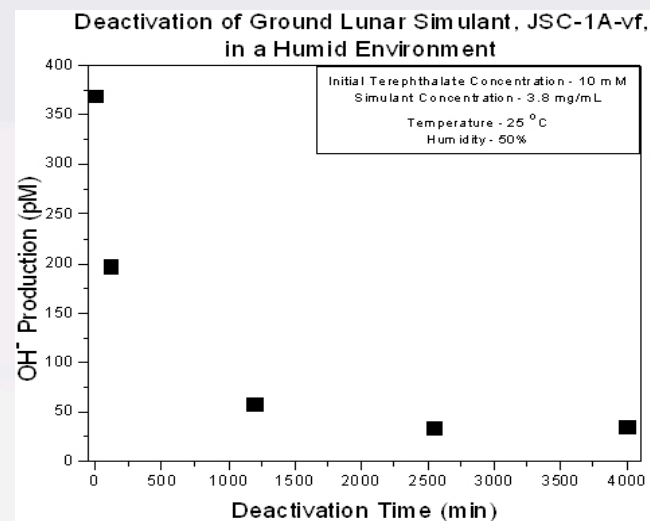
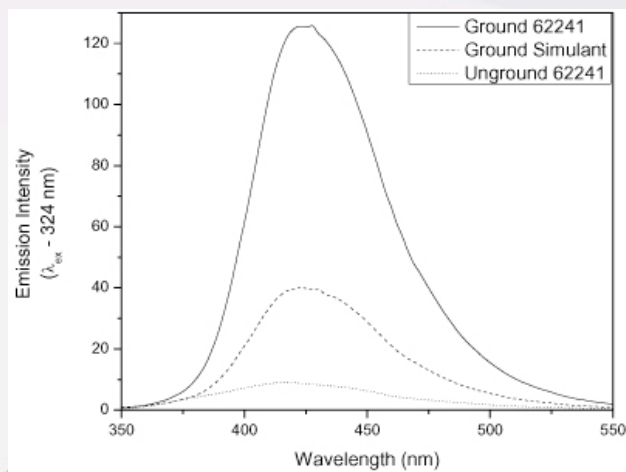
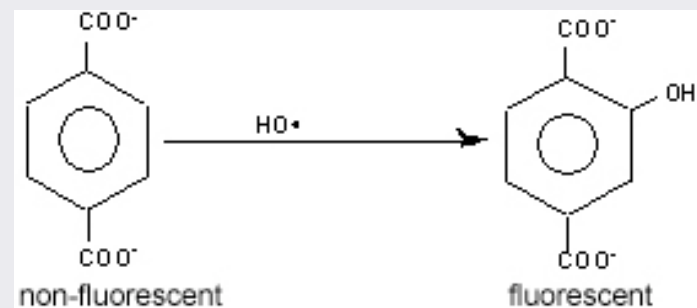


Dr. Antony Jeevarajan
JSC



Strategies for analyzing Lunar Dust Chemical Reactivity

- Re-activation of archived lunar dust specimens:
- Exposure to proton sources?
- Exposure to UV?
- How to assess the re-activated lunar dust?
 - Terephthalate Assay
 - Passivation Studies





Lunar Dust Samples from the Apollo Era

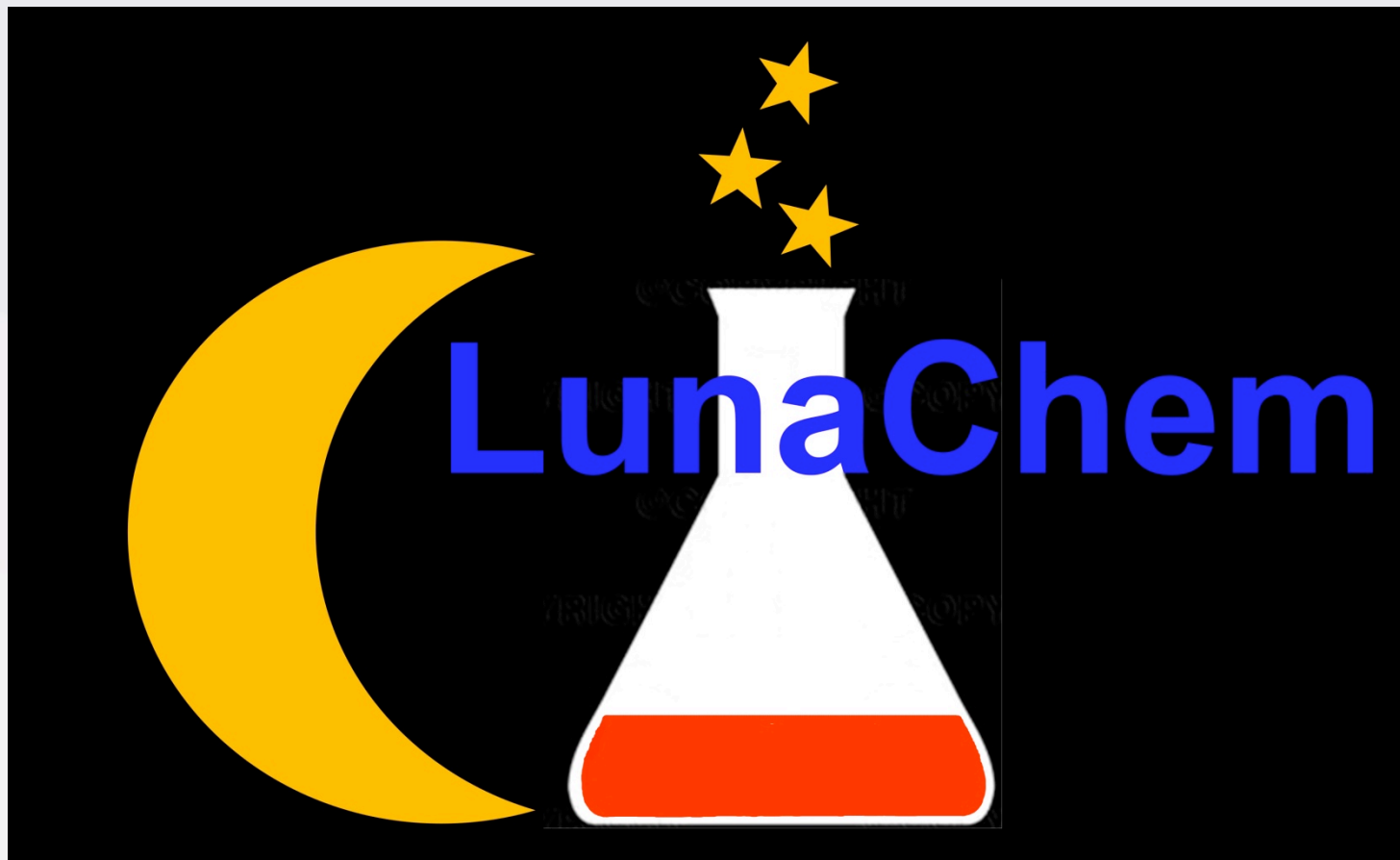
Problem: Lunar Dust samples from the Apollo Era (CAPTEM) are contaminated with ambient atmosphere.

Chemical reactivity has very likely been lost

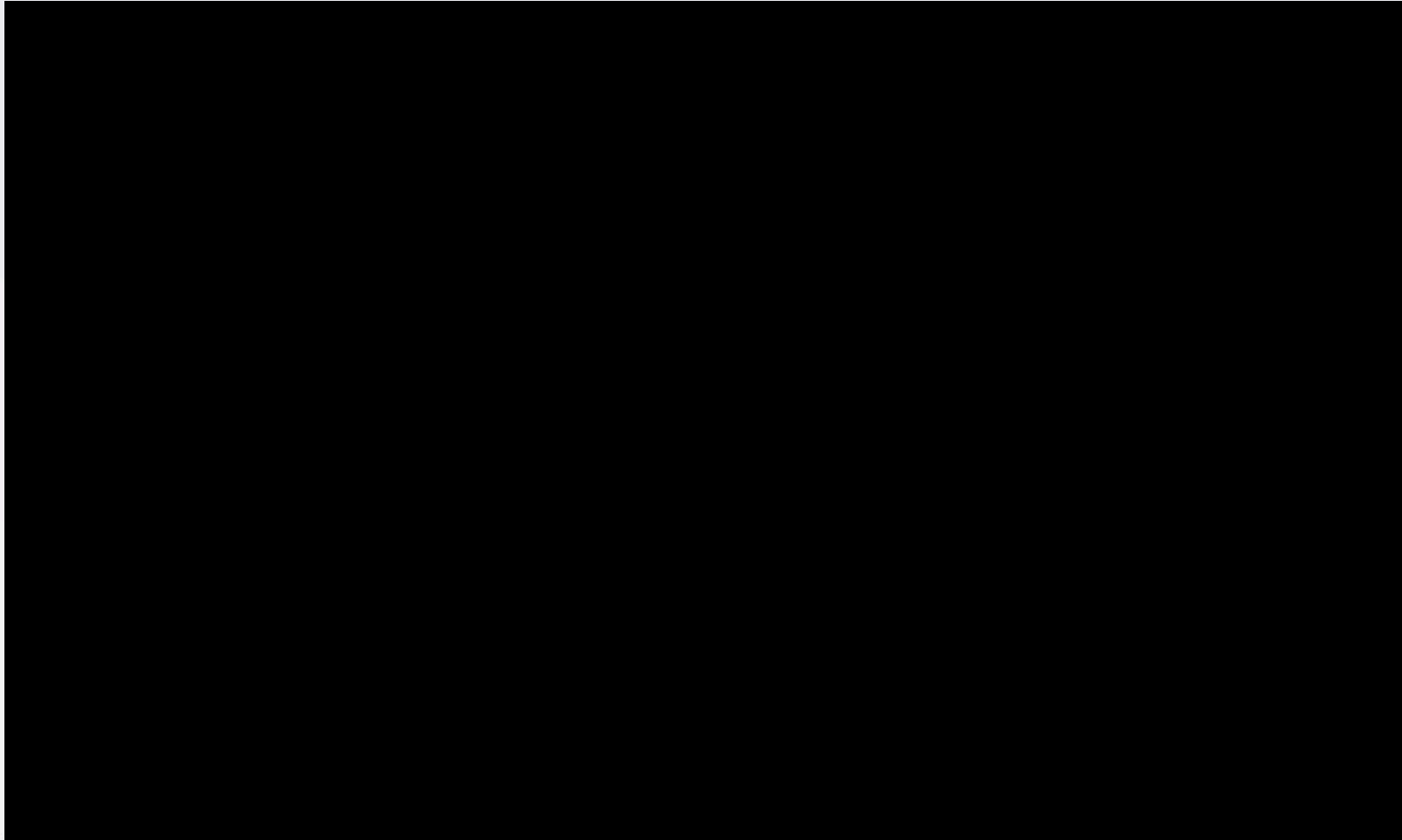
Question: Can we transport our lunar dust chemical reactivity analysis to the lunar surface?

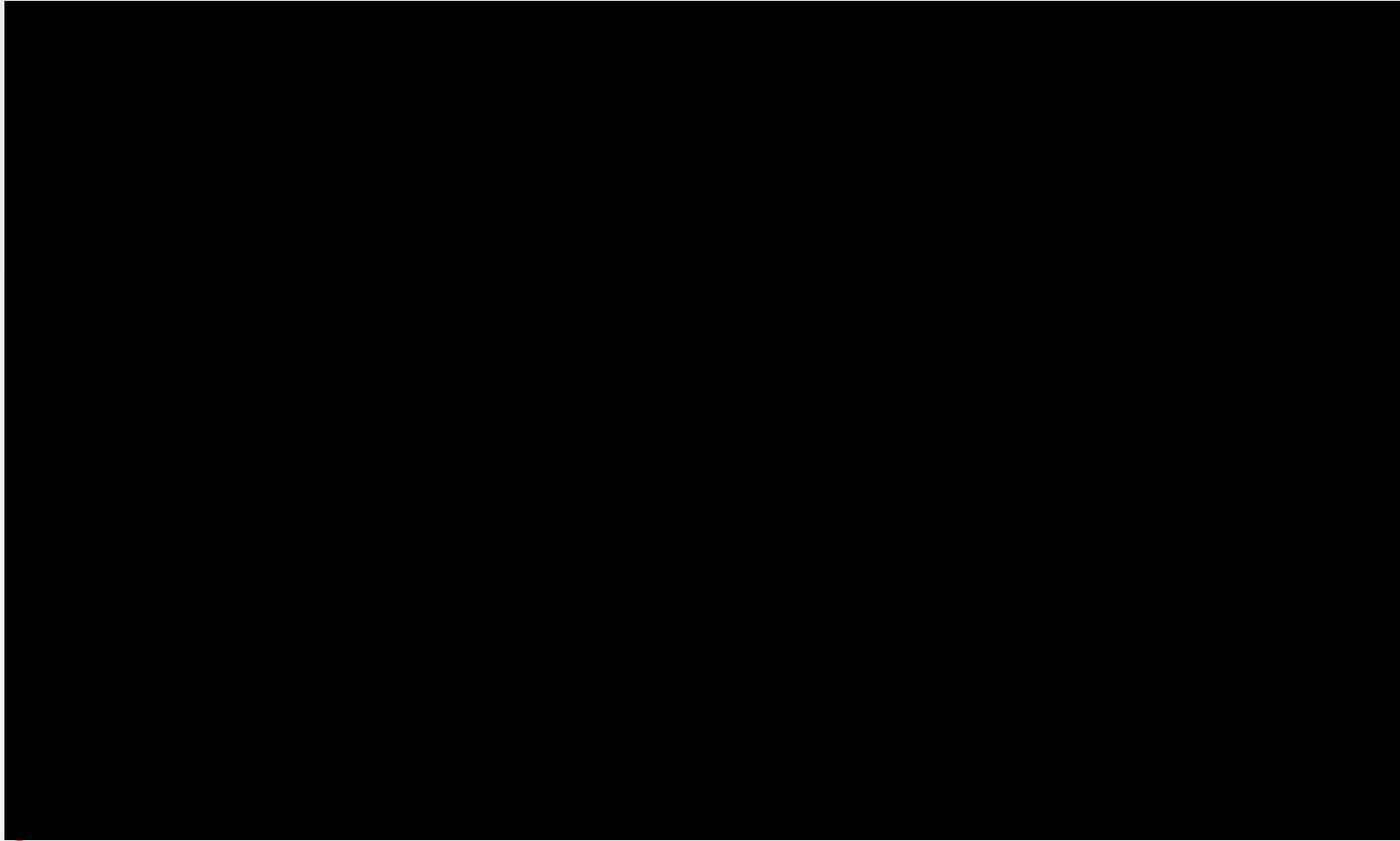
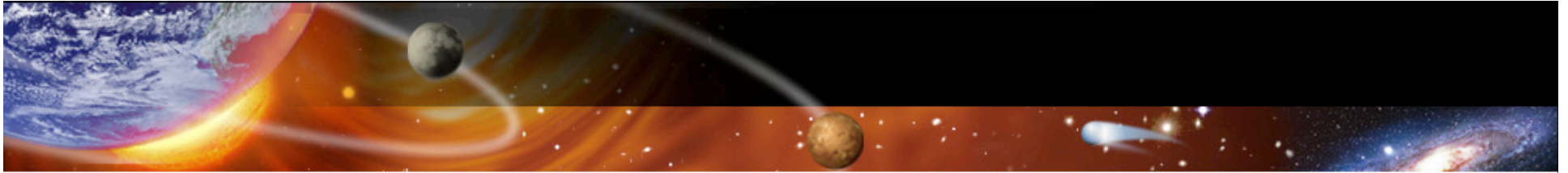


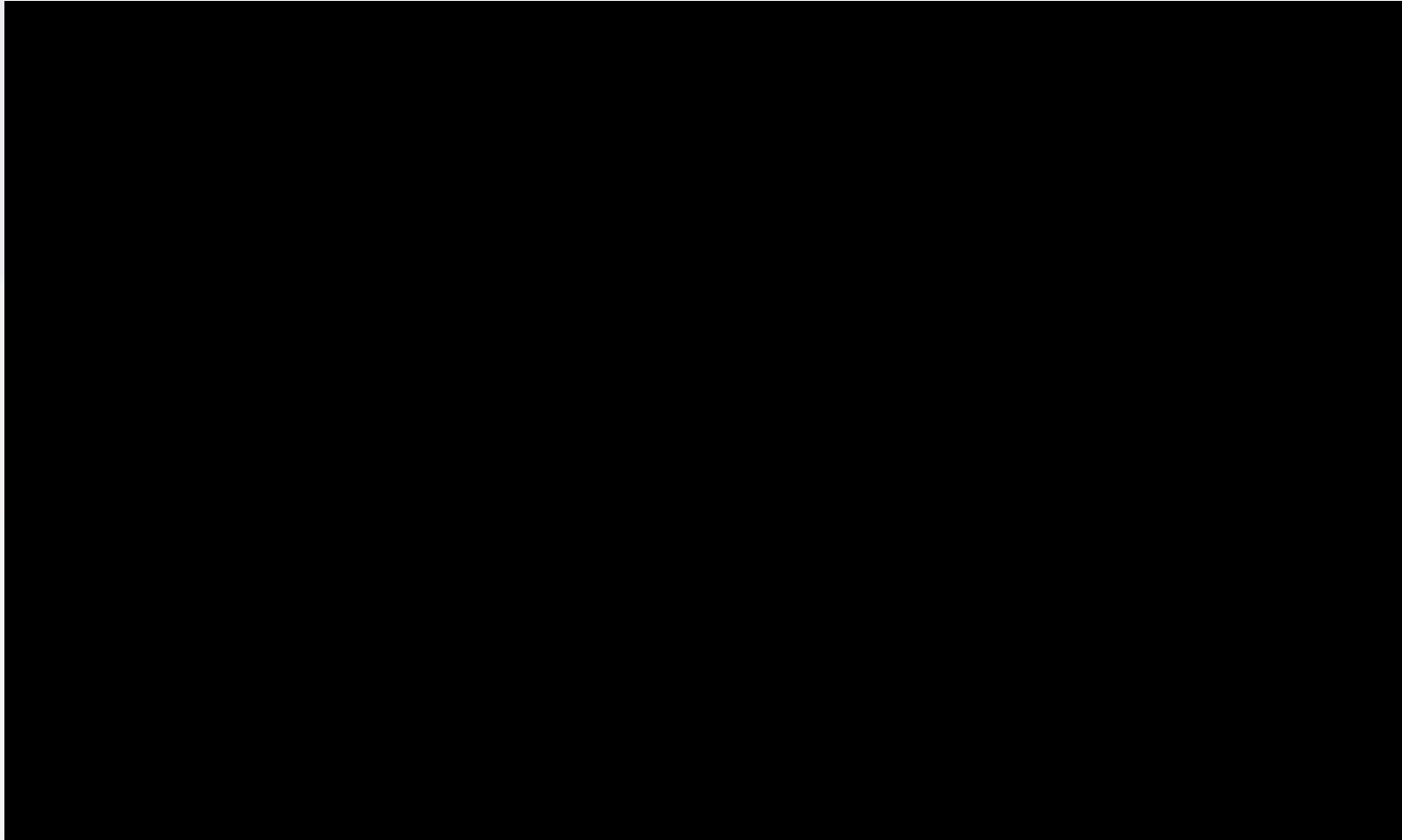
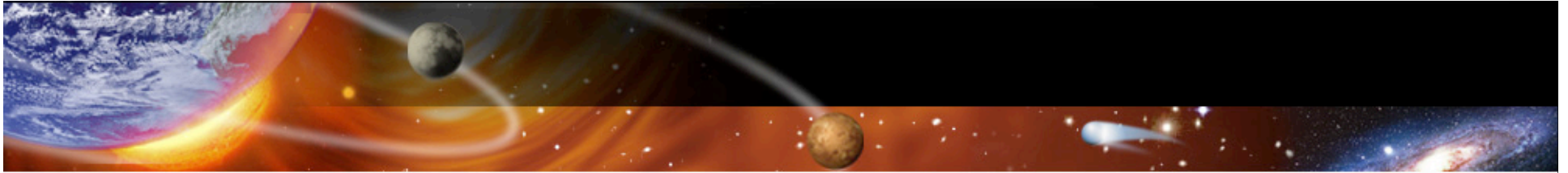
LunaChem--an instrument for determining lunar dust chemical reactivity

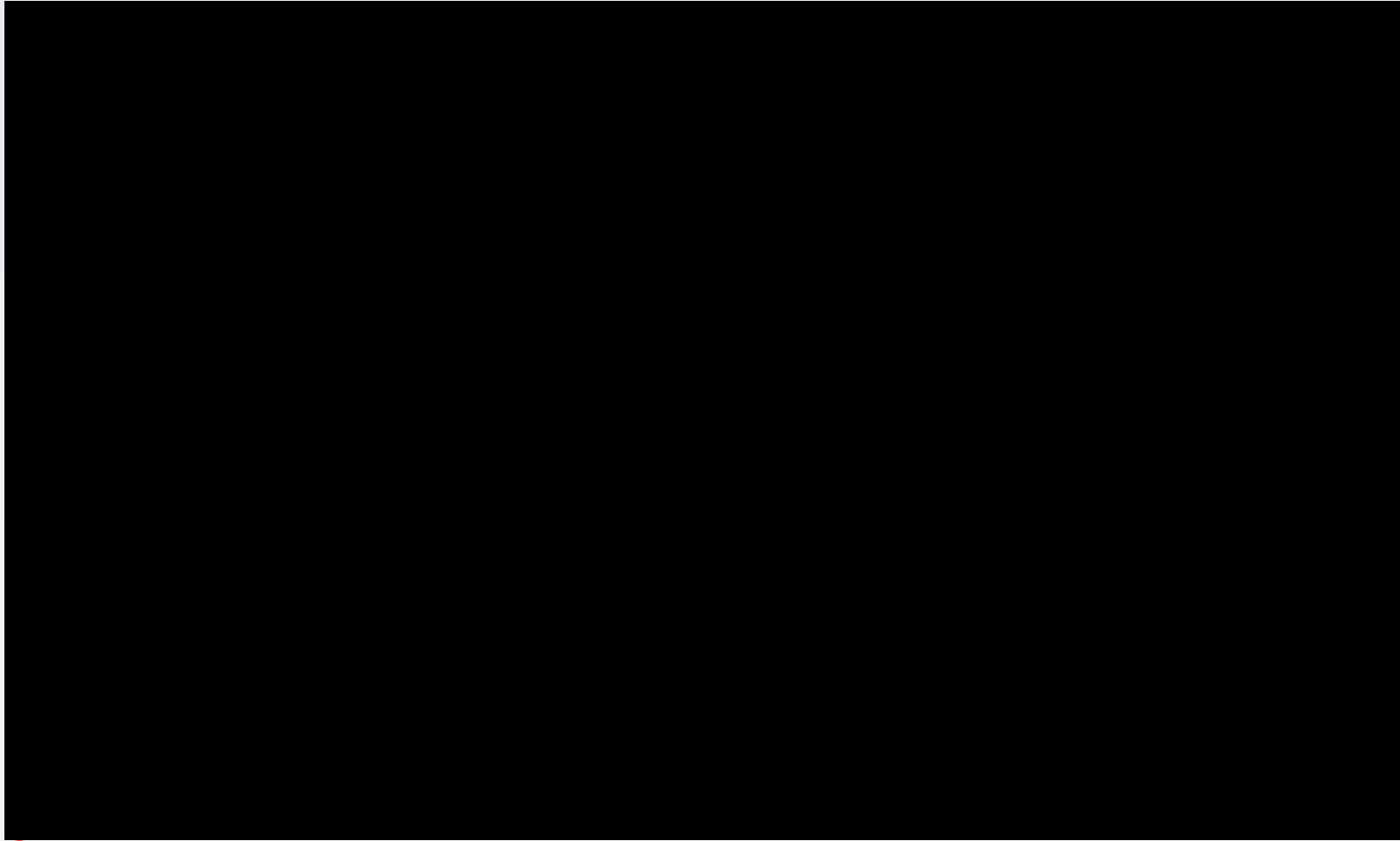
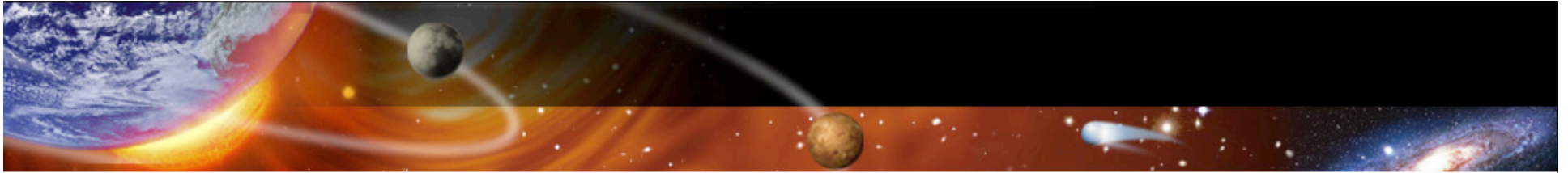


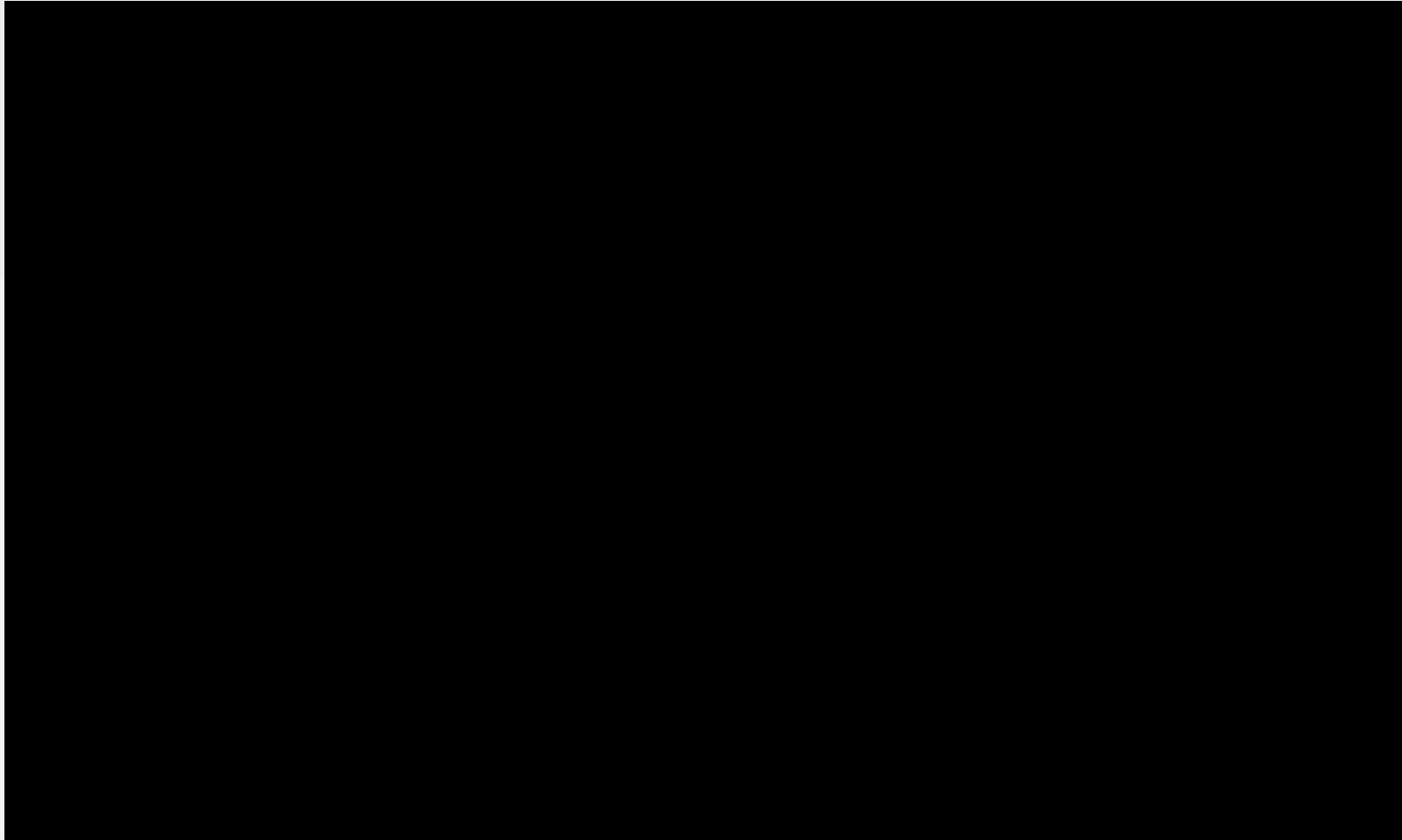
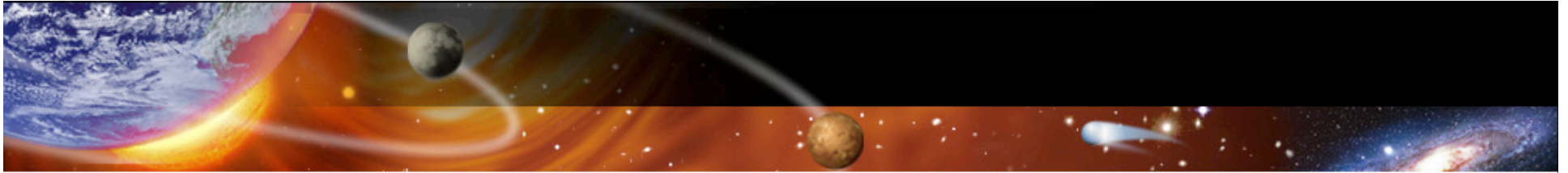
LunaChem

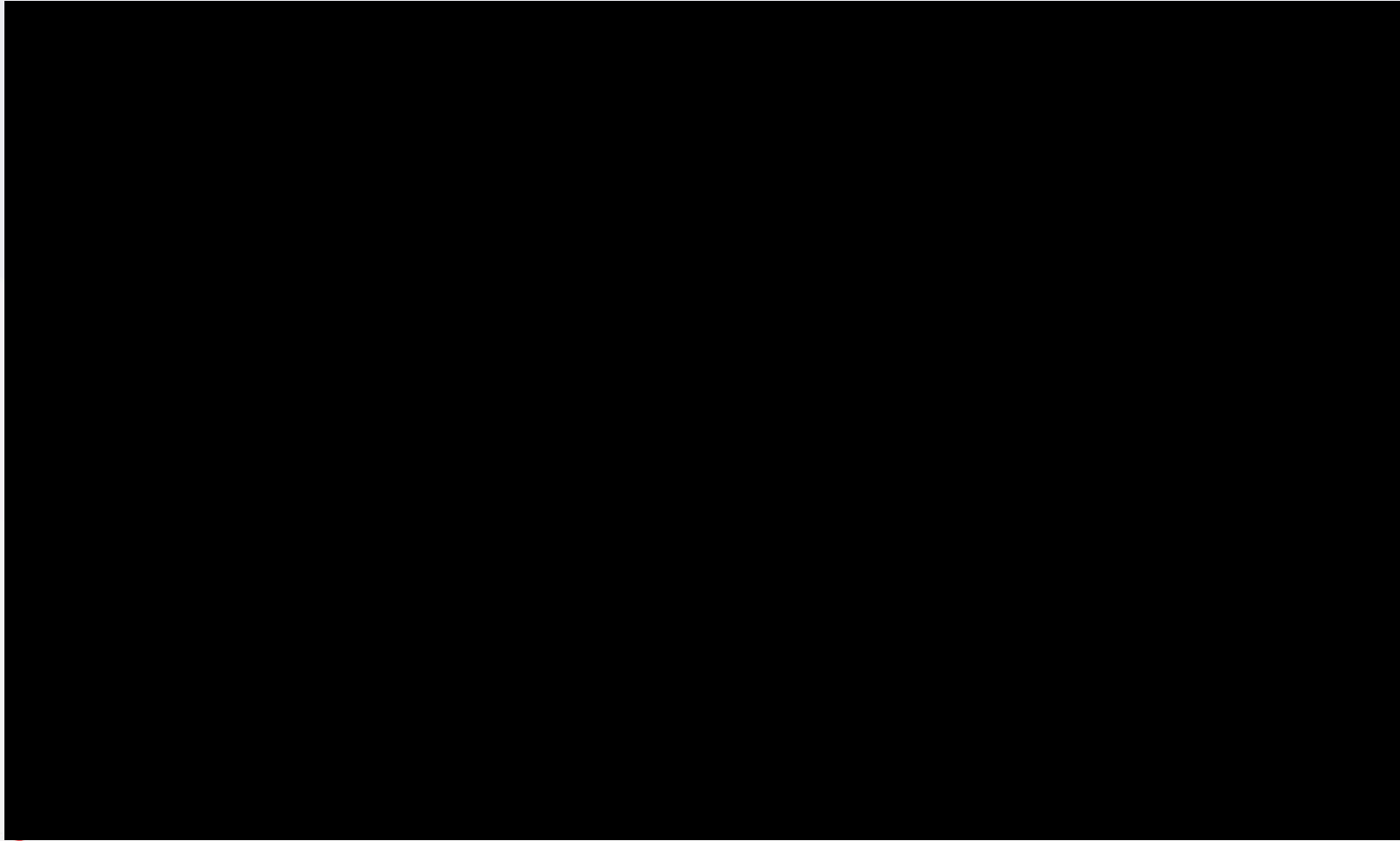
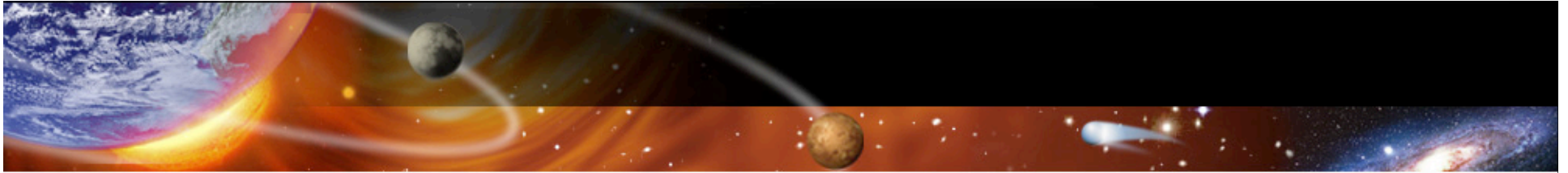


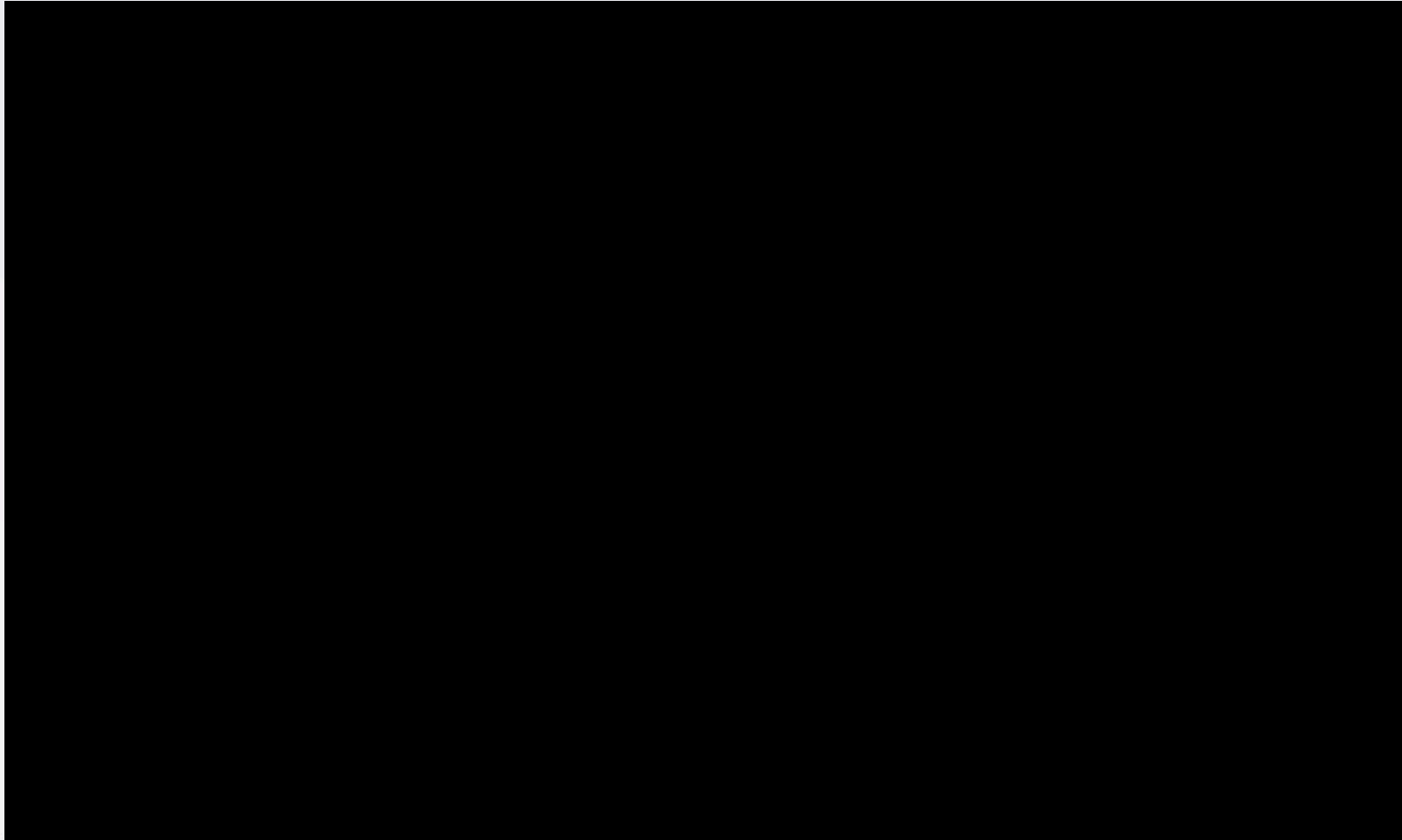
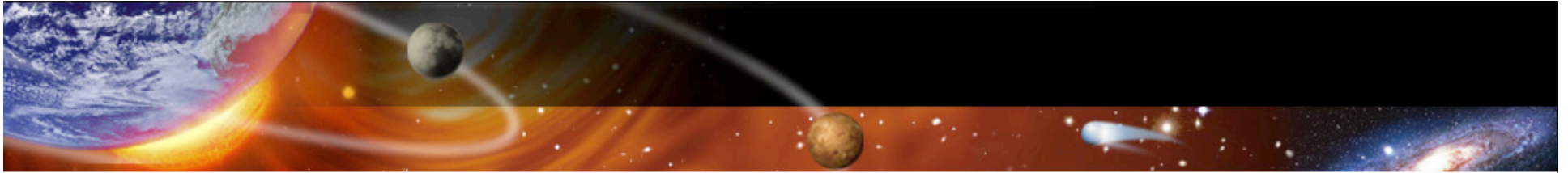


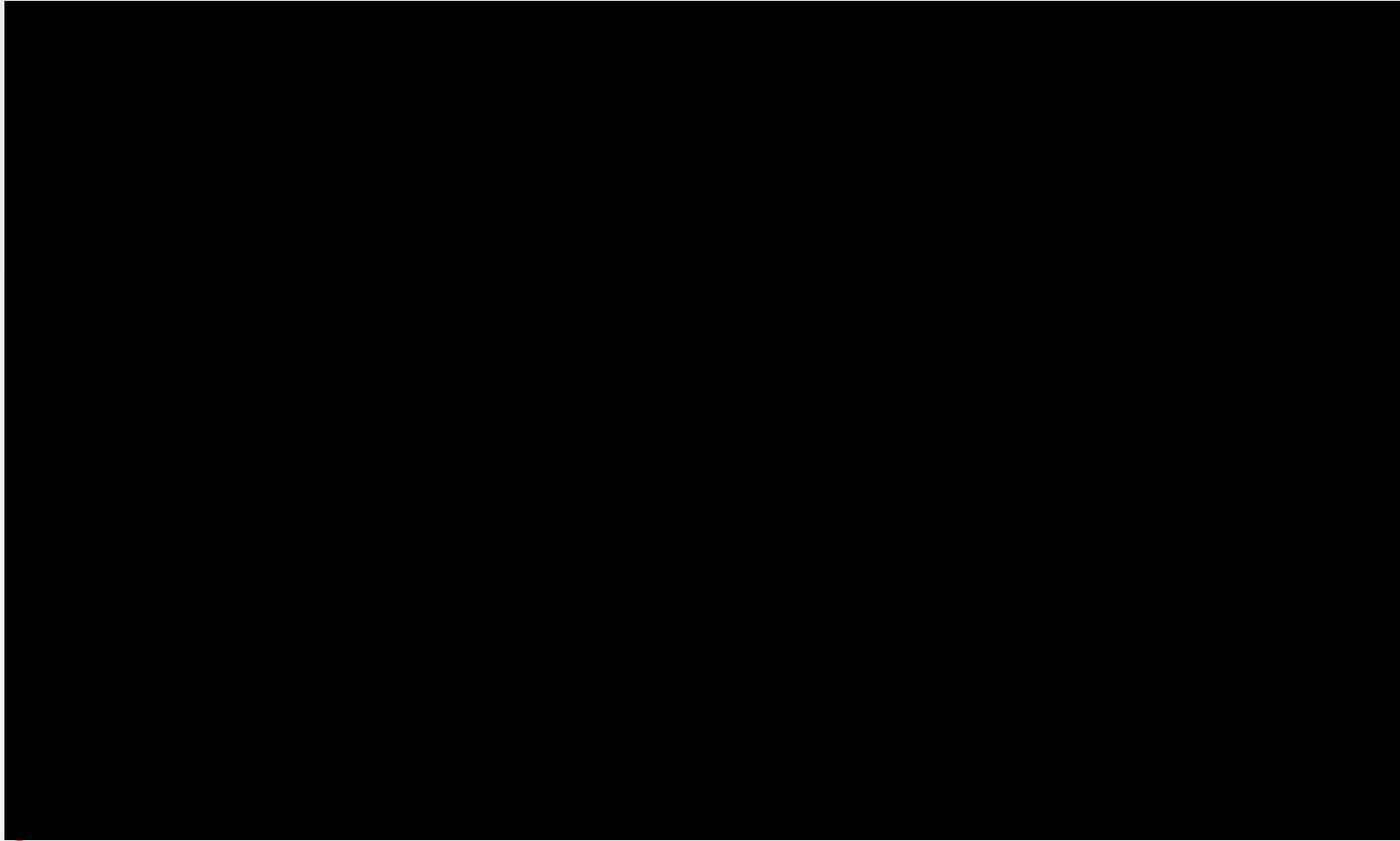
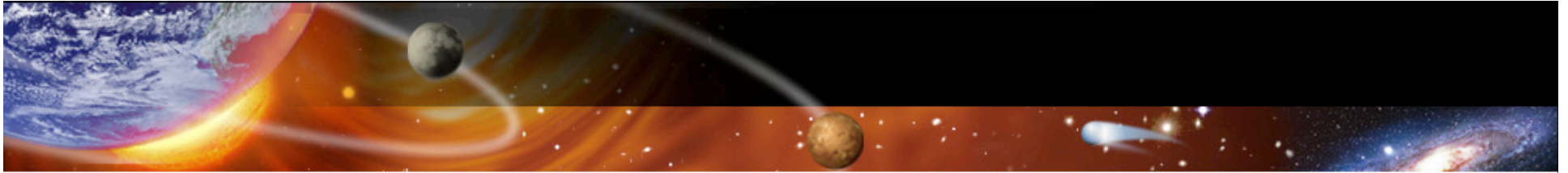


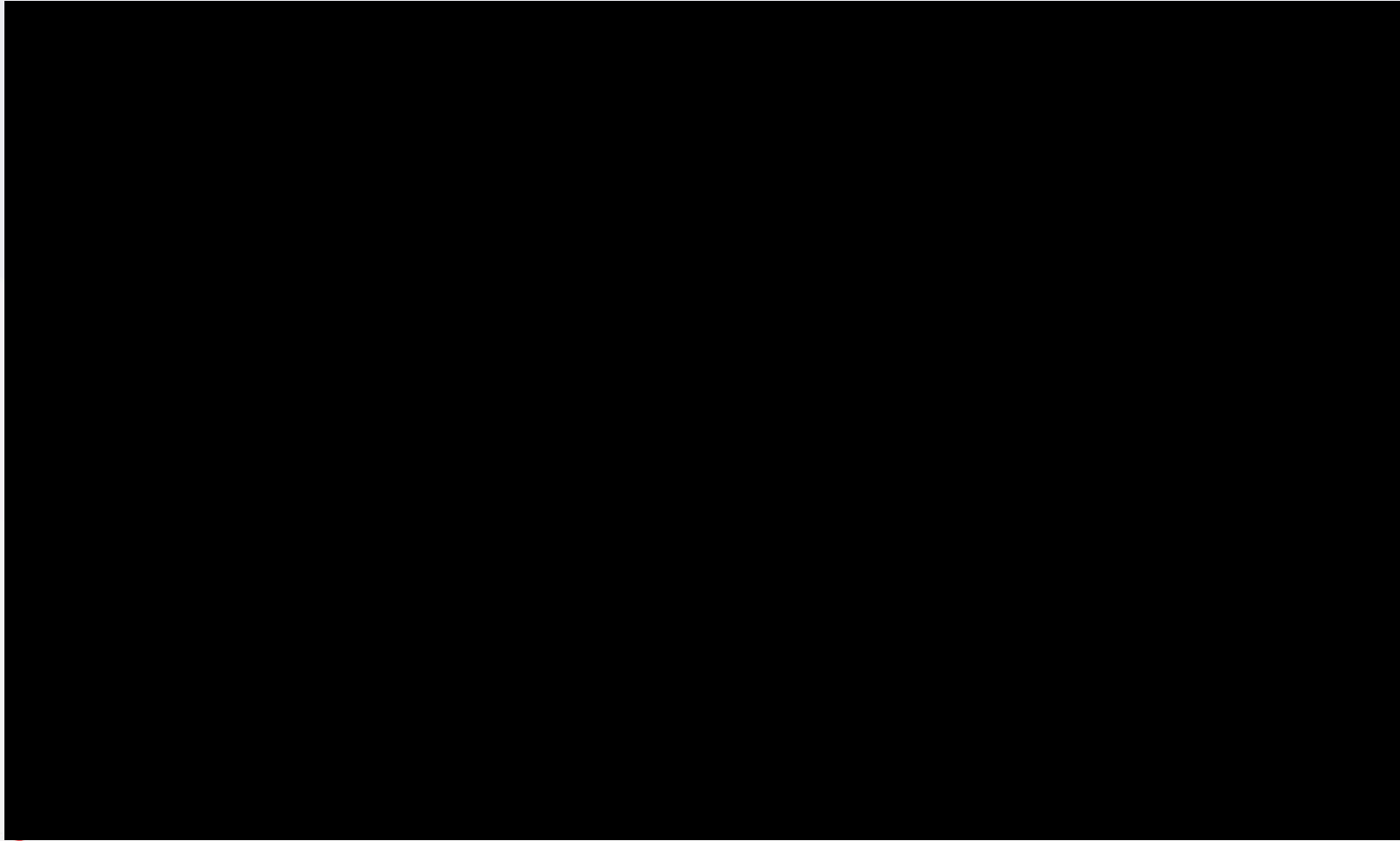
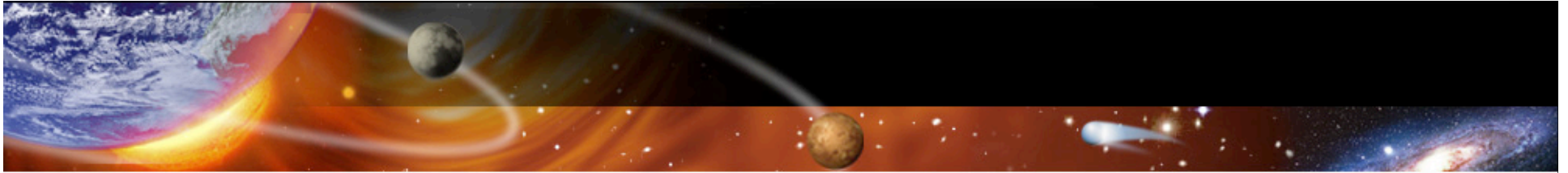


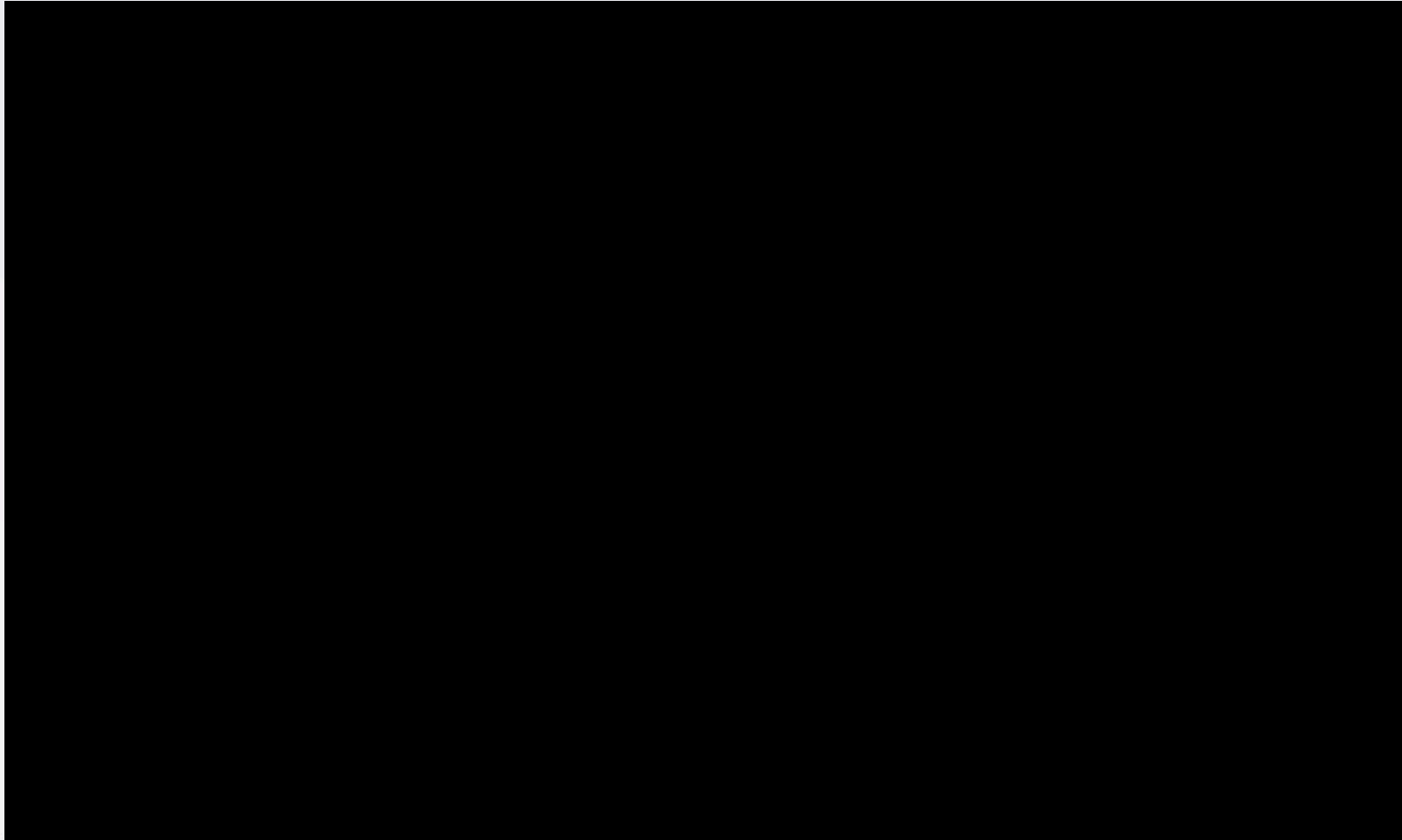
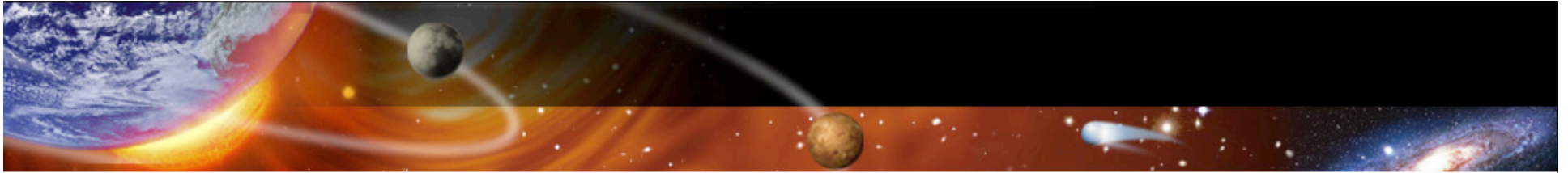


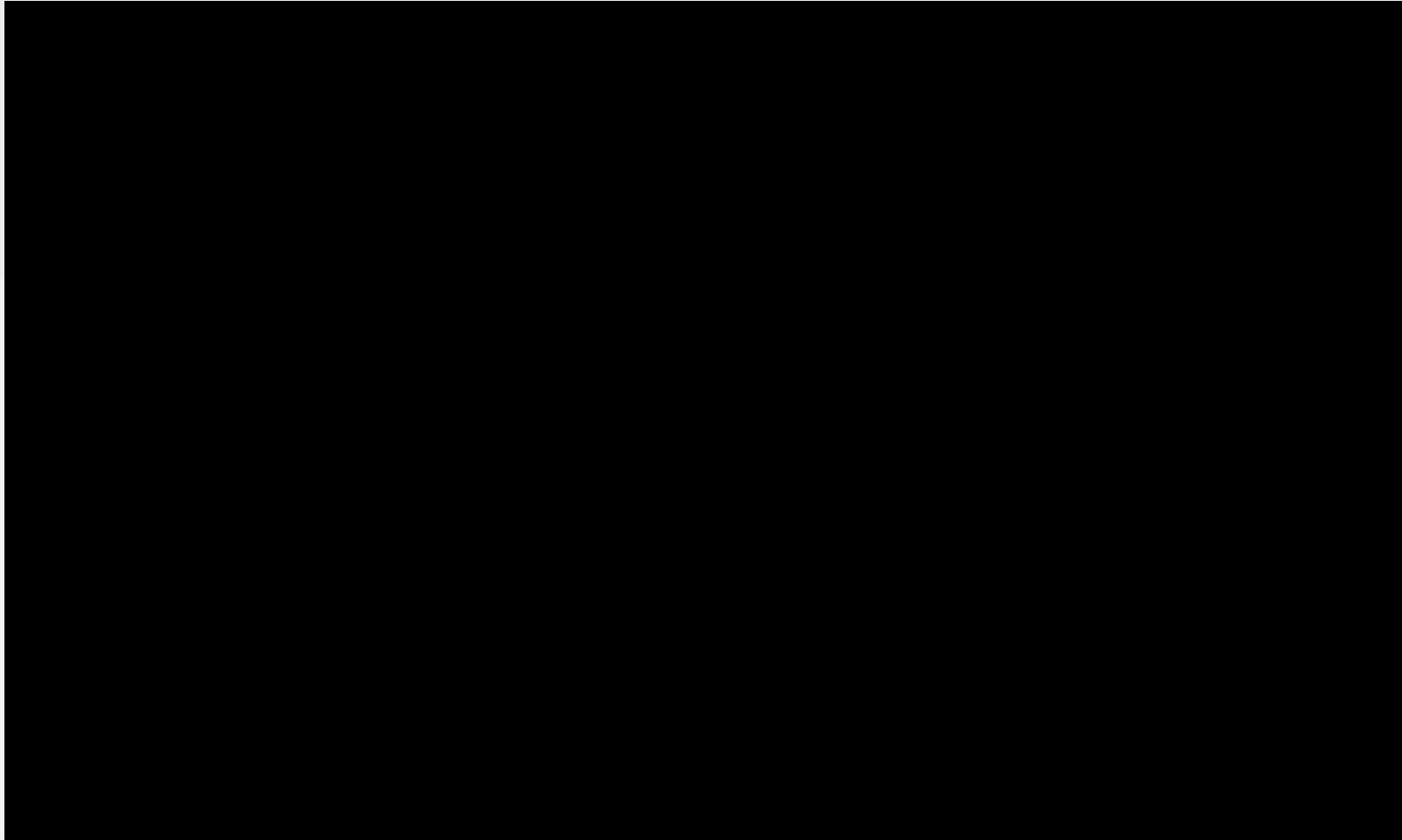
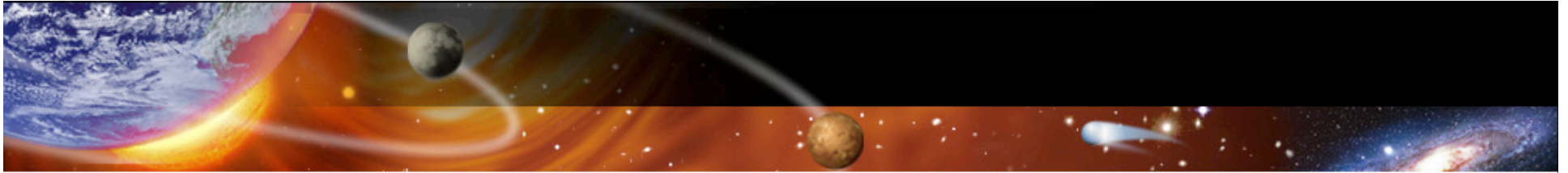


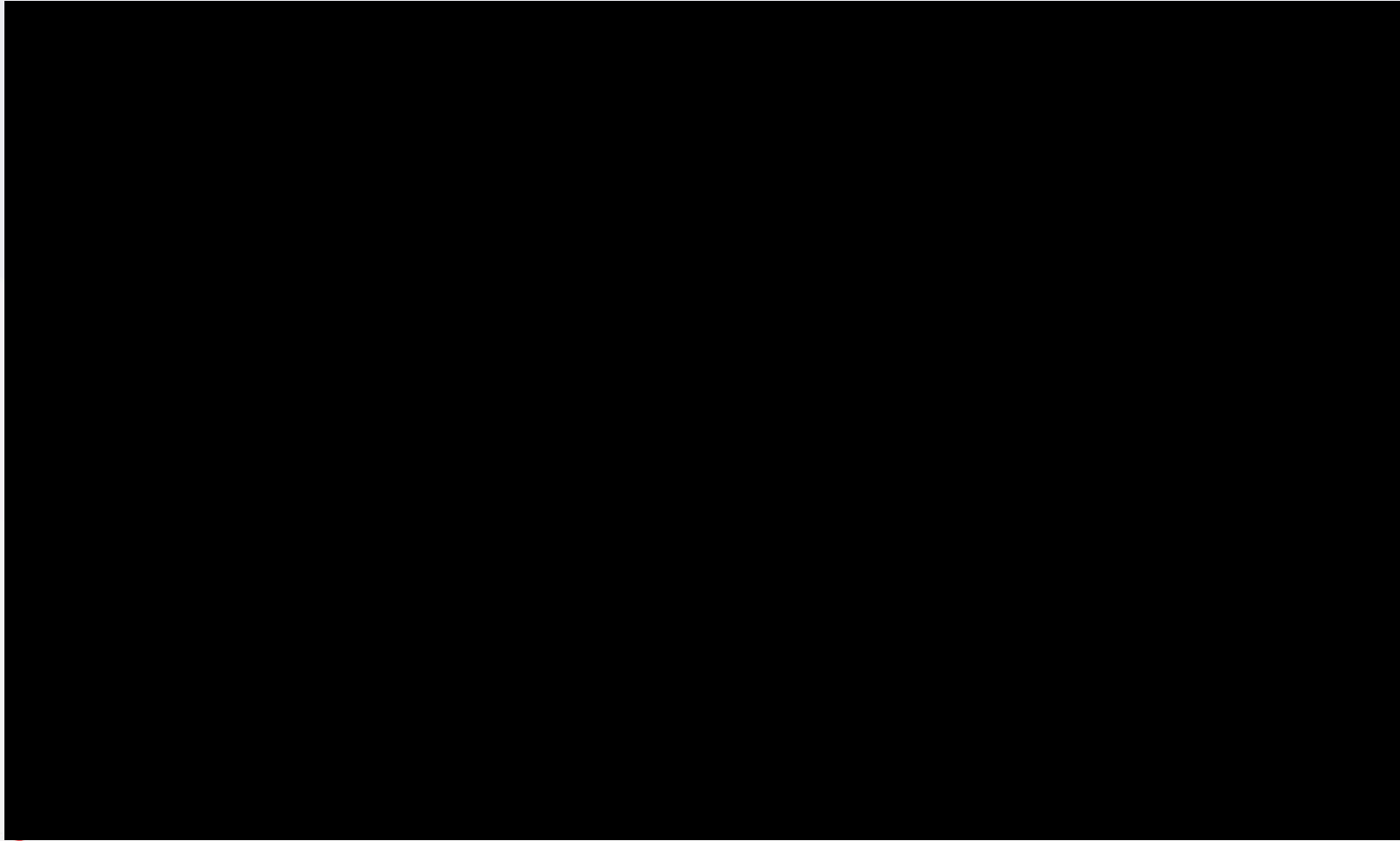
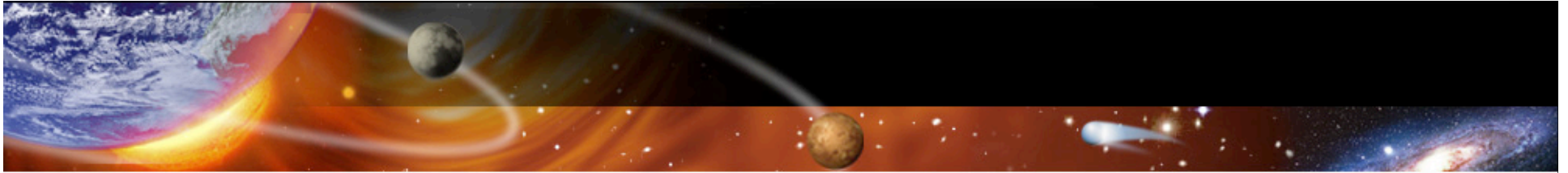


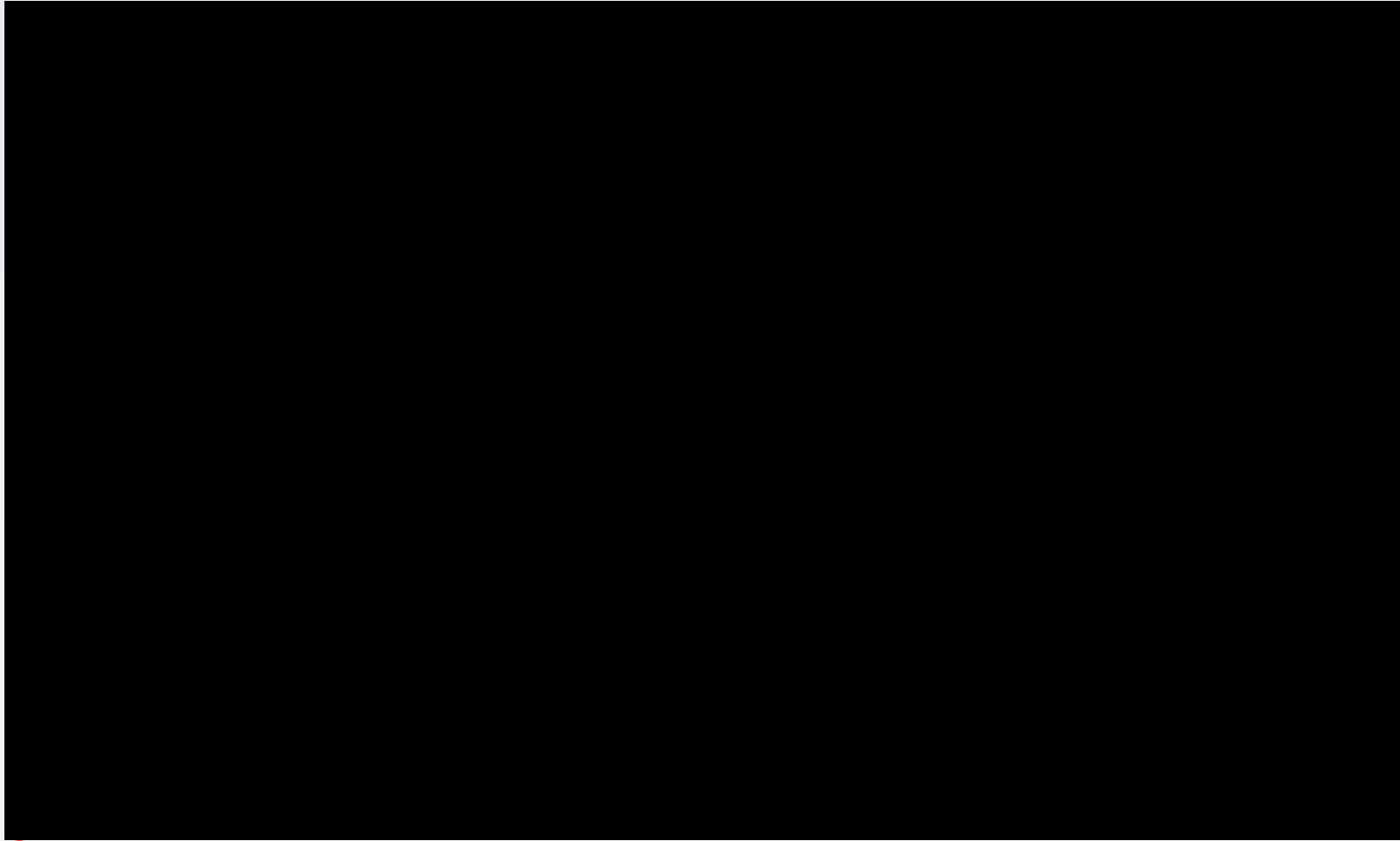
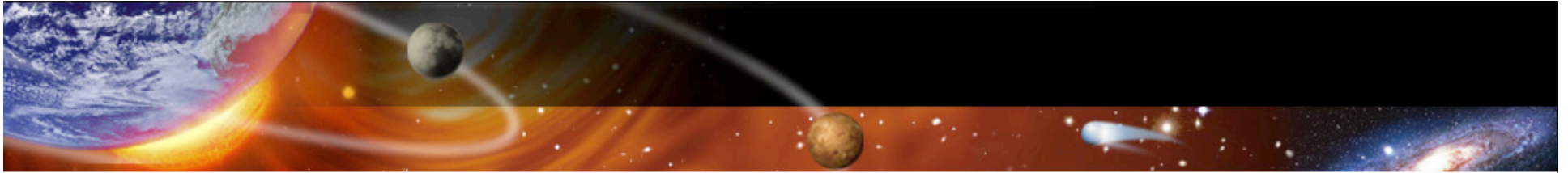


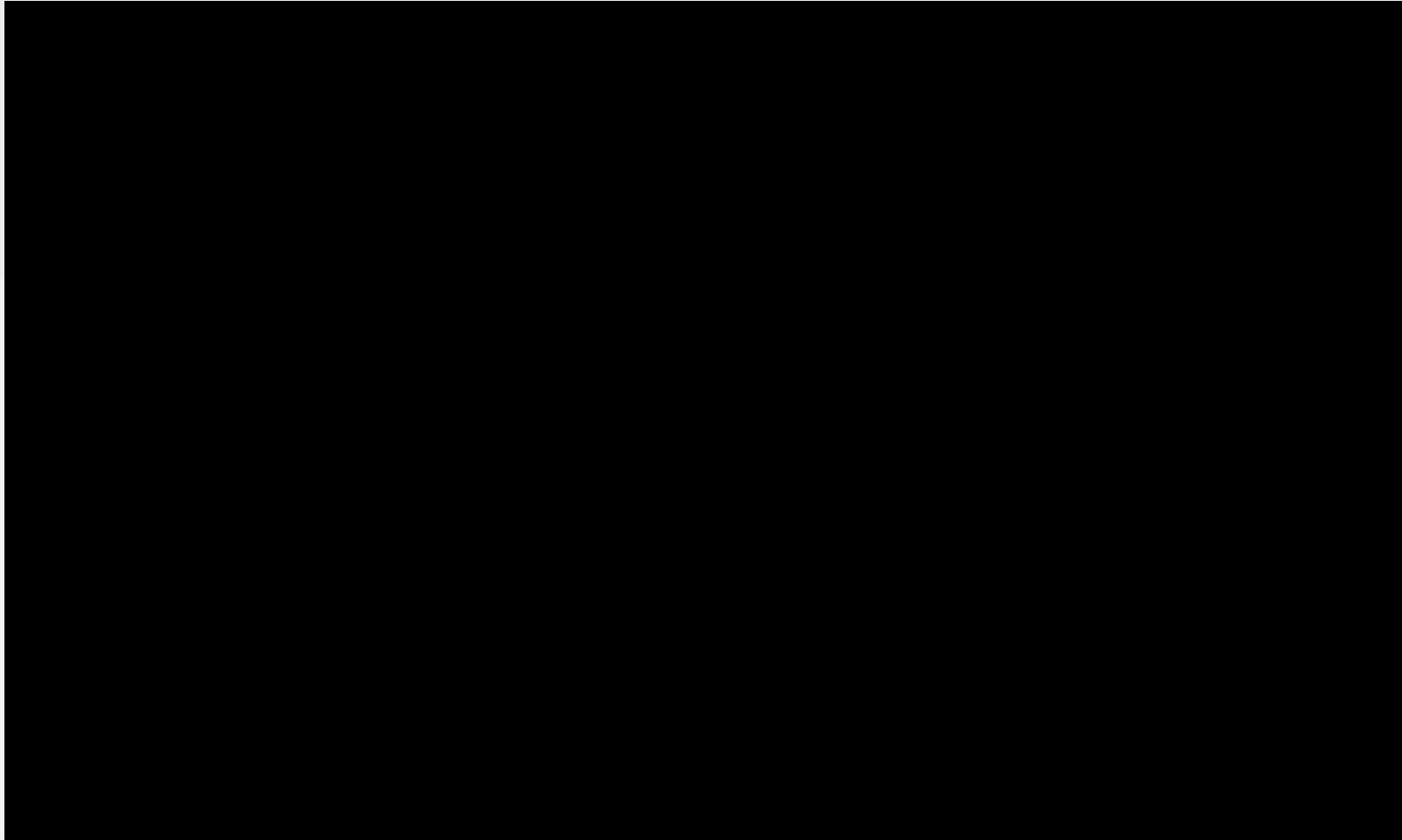
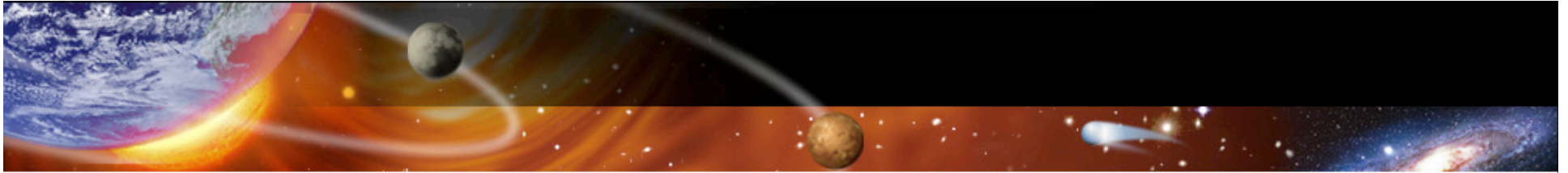


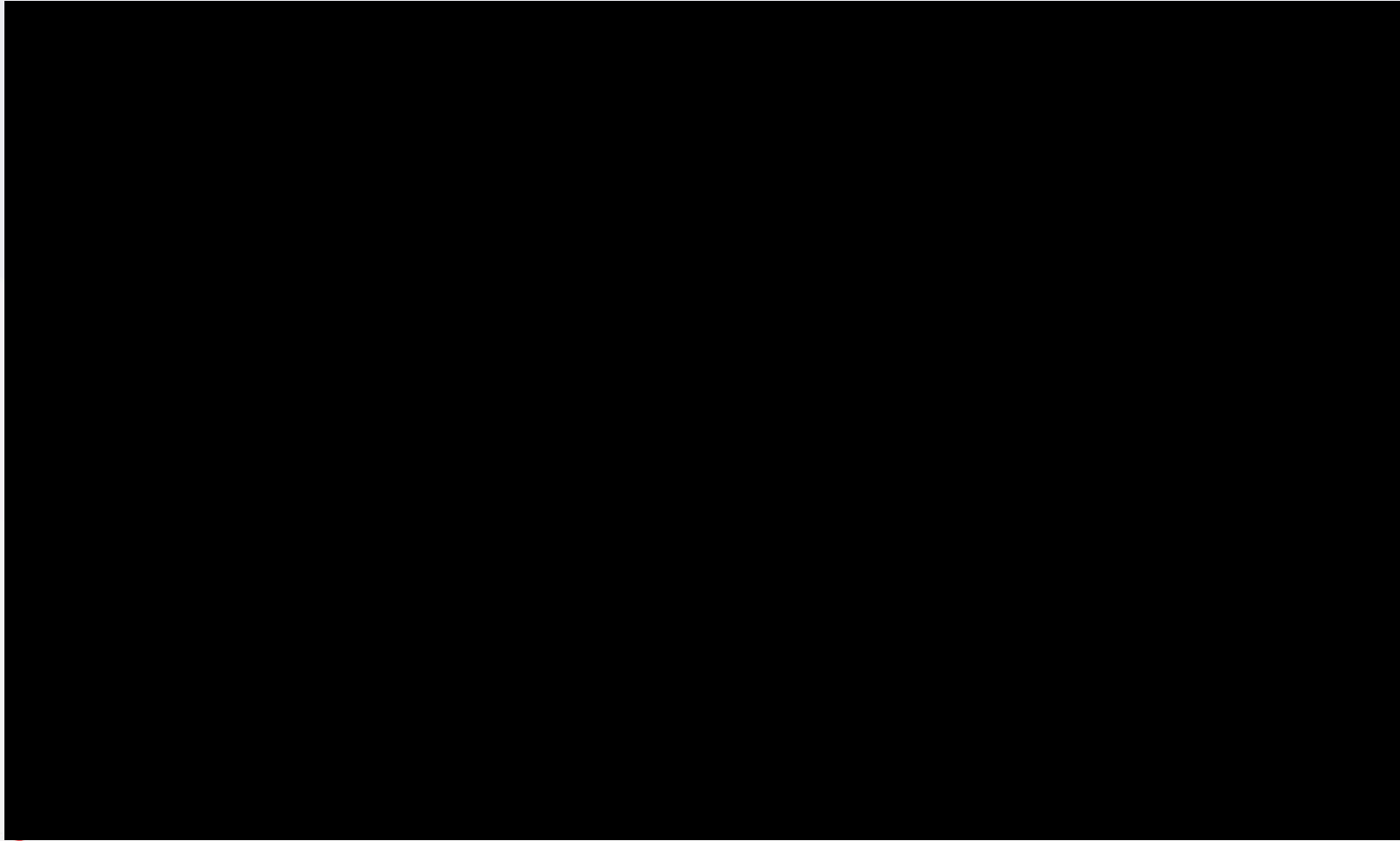
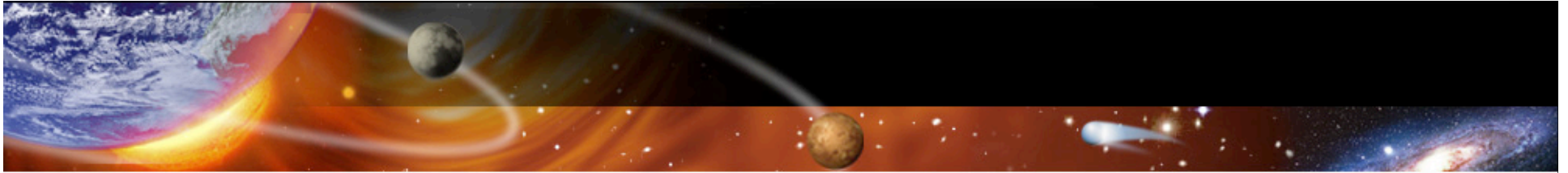


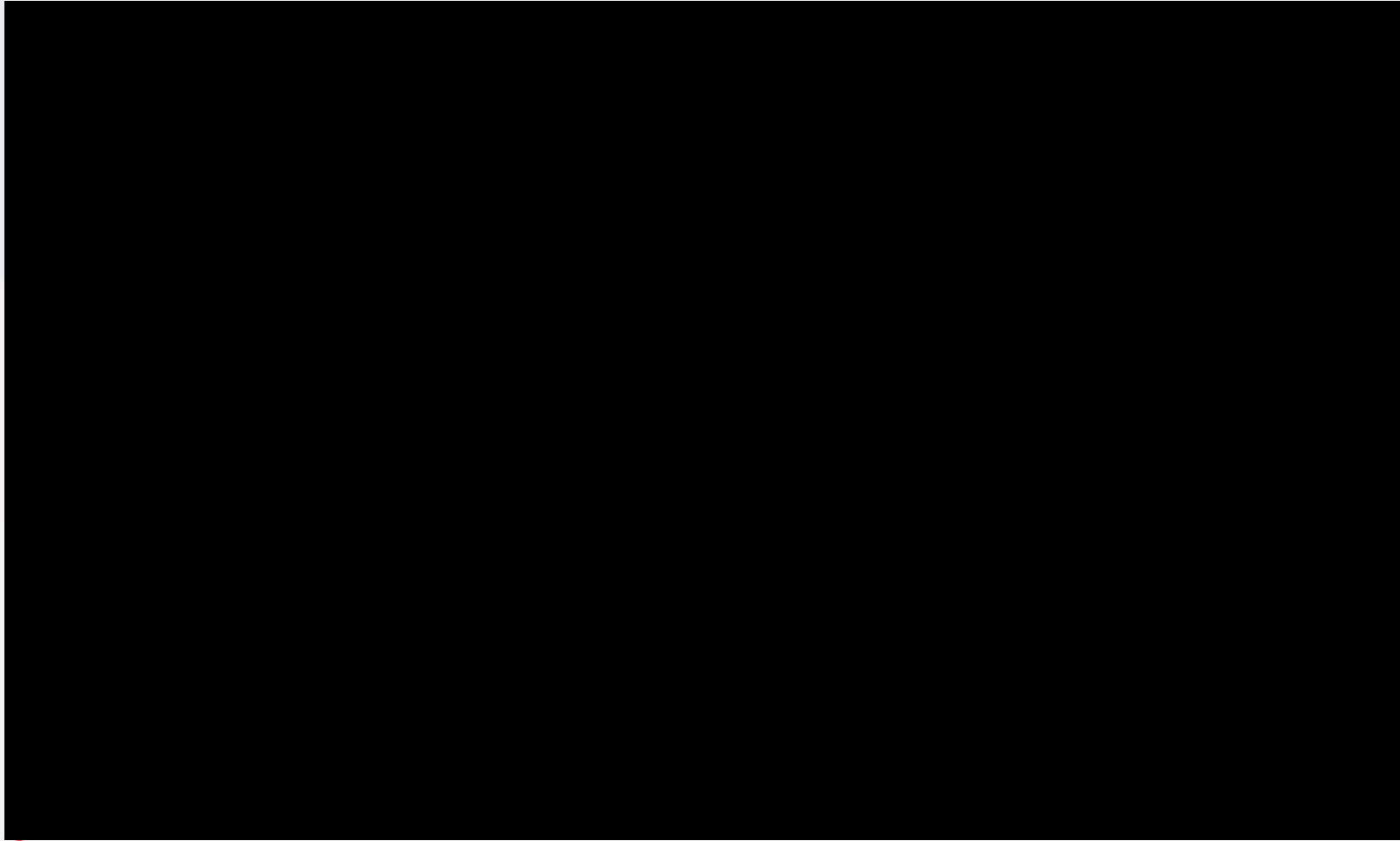
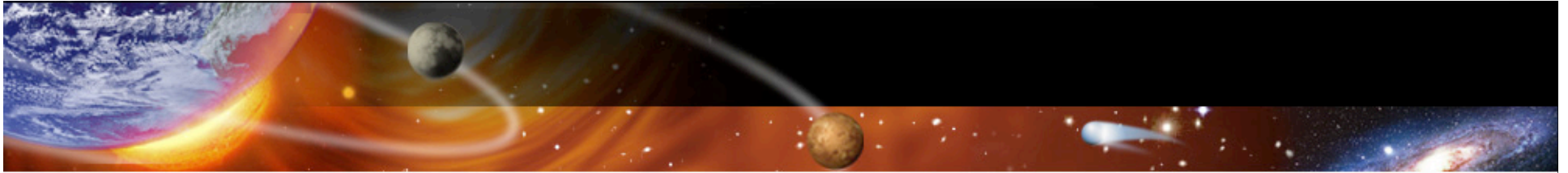


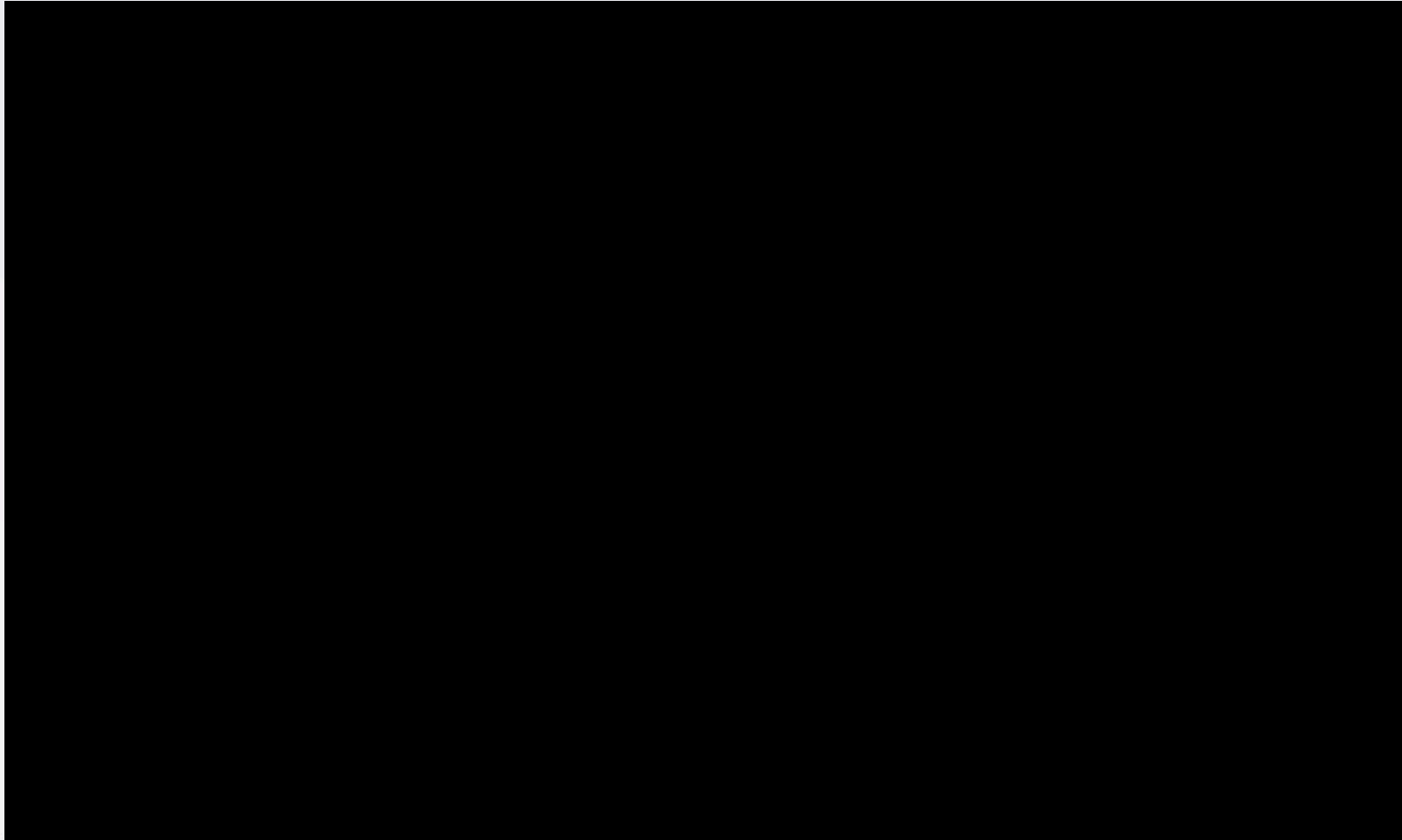
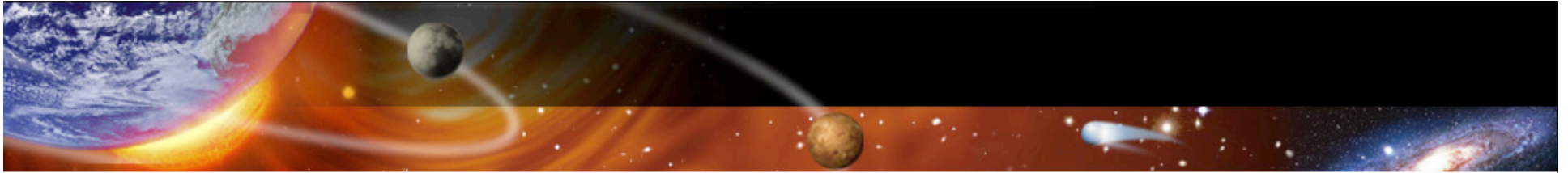


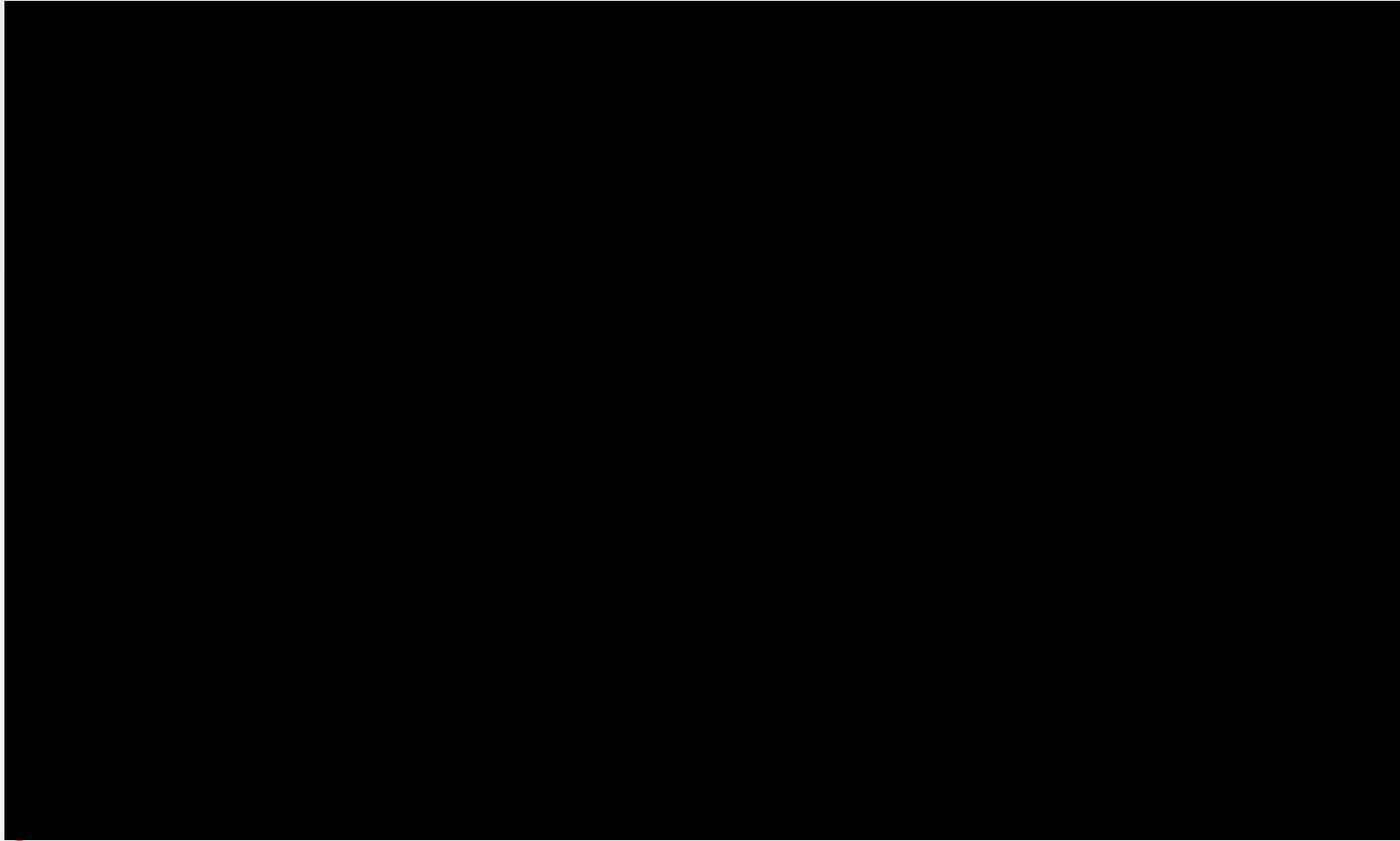
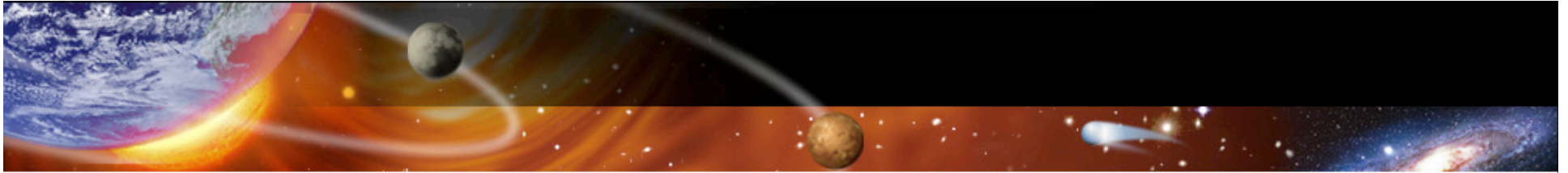


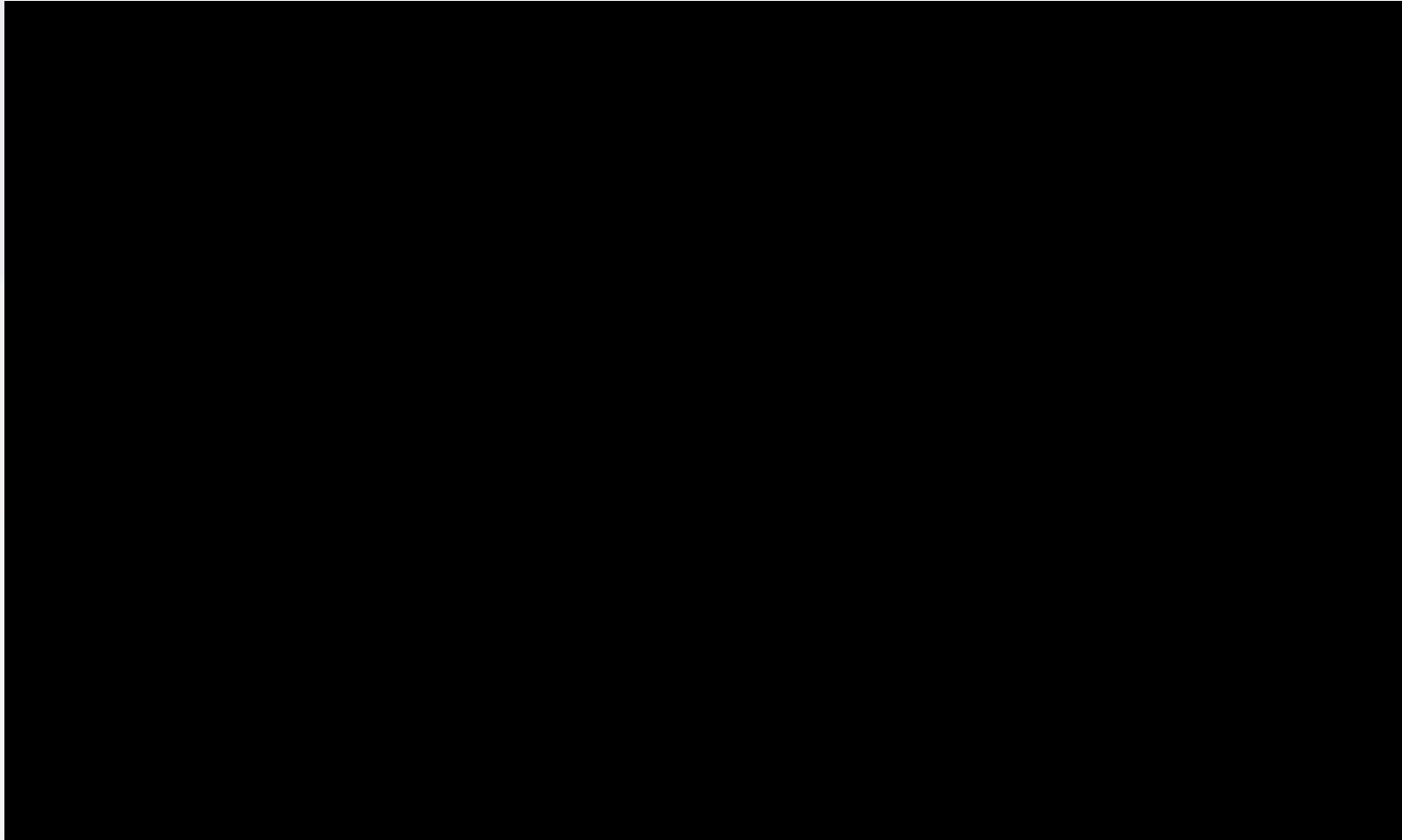
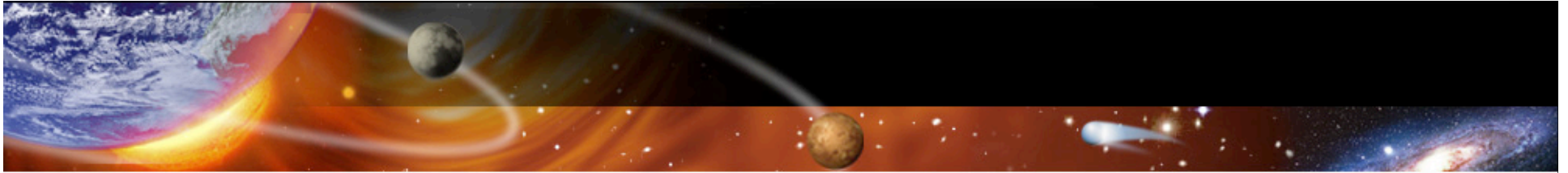















LunaChem--Summary

- Answers the most critical question about lunar dust chemical reactivity pertinent to biological systems
- Uses the same chemical assay (terephthalate) that we are using for ground-based studies.
- 5kg, 5W
- Suitable as a secondary payload aboard a lunar lander (soft landing, obstacle avoidance/site selection)





Summary

- We are engaged in ground-based studies of lunar dust “chemical reactivity” that address the most critical aspect of lunar dust interaction with biological systems, pertinent to the risk of pulmonary toxicity of lunar dust.
- These studies will have important ramifications for the interaction of lunar dust with non-human biological systems as well.
- *In situ* measurements are needed to fully understand the chemistry—LunaChem can provide these measurements.

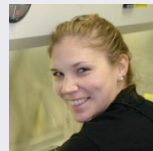


Human Resources/Expertise

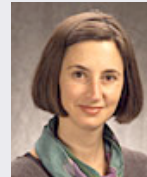
NASA Ames Research Center



Meryl Lee Corcoran
Animal handling



Erin Tranfield, Ph.D.
Particle toxicology, ITI, EM



Wenonah Vercoutere, Ph.D.
Chemistry, nanotechnology



Jon Rask
Biology, cell biology, ITI



Russ Kerschmann, M.D.
Pathology (derm)



Clara McCrossin
Student, Biology, Chemistry



Human Resources

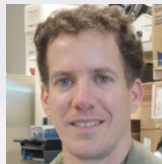
**National Institute of
Occupational Safety
and Health (NIOSH),
Morgantown**



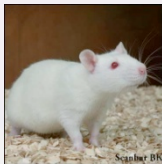
Vince Castranova
Pulmonary toxicology



Dale Porter
Pulmonary toxicology



Michael Wolfarth
Pulmonary toxicology, ITI



Mark Barger
Pulmonary toxicology, ITI

